W/Z + Heavy Flavor Production and SM Higgs Searches at the Tevatron

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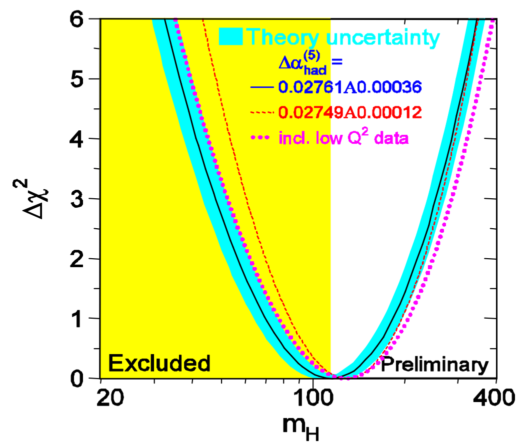
for DØ and CDF Collaborations

Covered in this talk

- **W + heavy flavor and WH searches**
- **Z + heavy flavor**
- **H→WW searches**

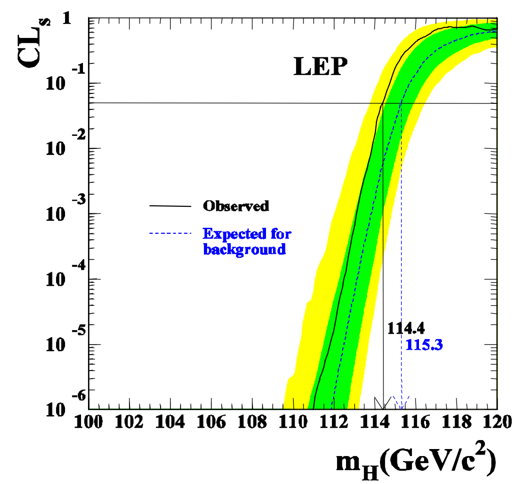
Experimental Limits on M_H

- Experimental limits
  - LEPEWWG fit updated for summer 04
    - $M_H = 114^{+69}_{-45}$ GeV
  - Direct searches from LEP
  - ☞ Light Higgs favored



Electroweak Fit
$M_H < 260$ GeV
(95% CL)

- Tevatron
  - Precision $\mathbf{m_t}$ and $\mathbf{M_W}$ measurements
  - Direct Searches – High luminosity is required at the Tevatron to discover or rule out wide range of M_H through direct searches



LEP Search
$M_H > 114$ GeV
(95% CL)

SM Higgs Production at the Tevatron

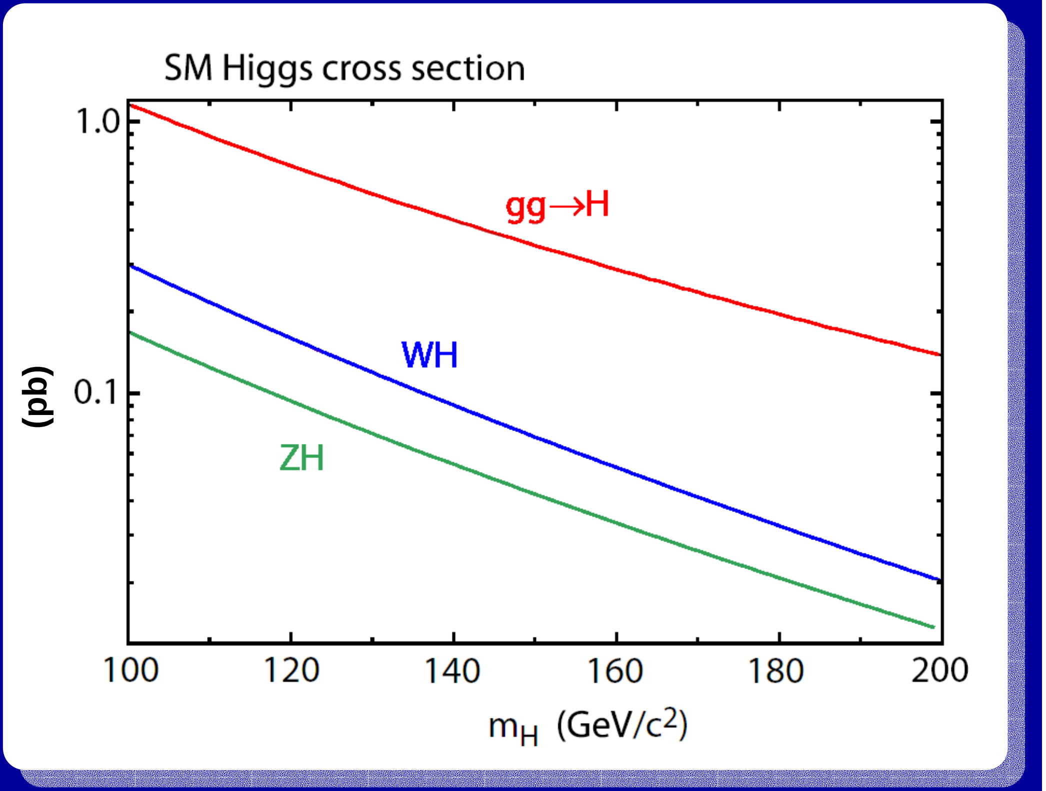
- Though Higgs production could be quite copious, not all channels are accessible

gg→H

– Relevant for M_H>140 GeV
– H→WW→llνν
– Background: WW

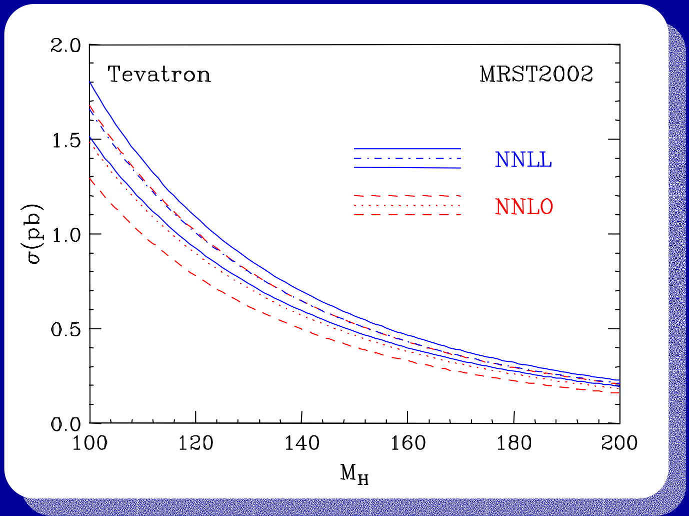
W/Z+H

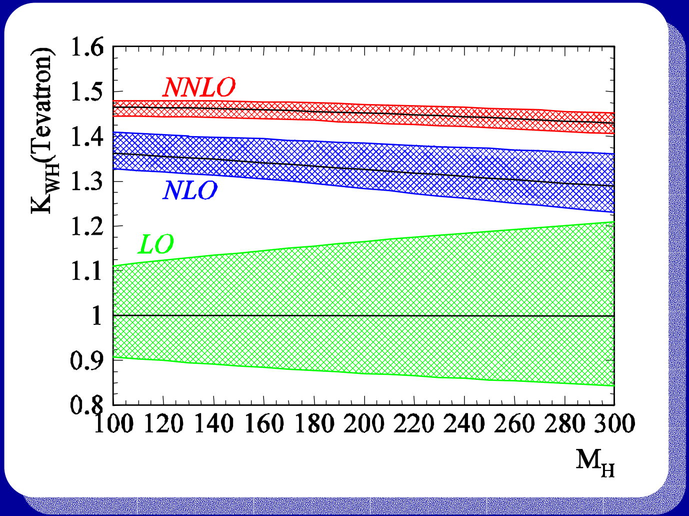
– M_H<140 GeV
– WH→lνbb
– ZH→llbb, ννbb
– Background: W+bb, Z+bb, top



Higher Order Production Cross Sections

- Signal processes
  - gg→H
    - NNLO adds ~30% relative to NLO cross sections
    - exhibits smaller depedence on scale
  - W/Z+H
    - NNLO 10% increase
    - Phys.Lett. B579 (2004) 149-156



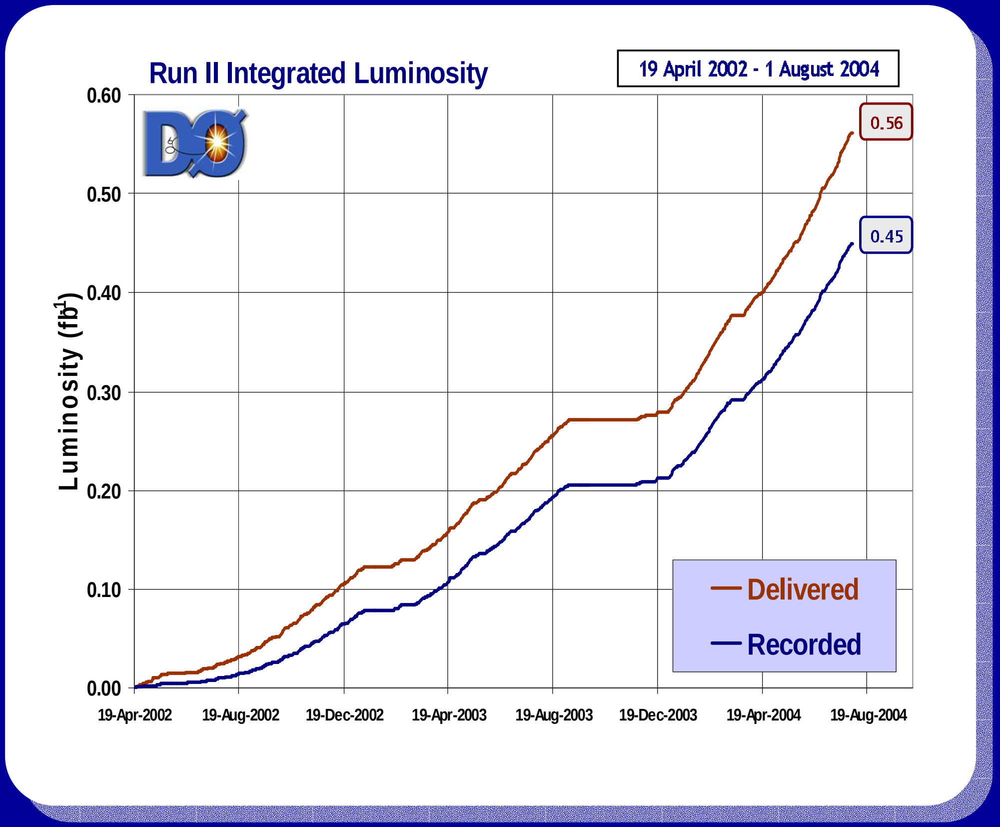


- Background processes
  - W/Z+jj and W/Z+bb at NLO
  - Available as MCFM program

    http://mcfm.fnal.gov/

Tevatron Status

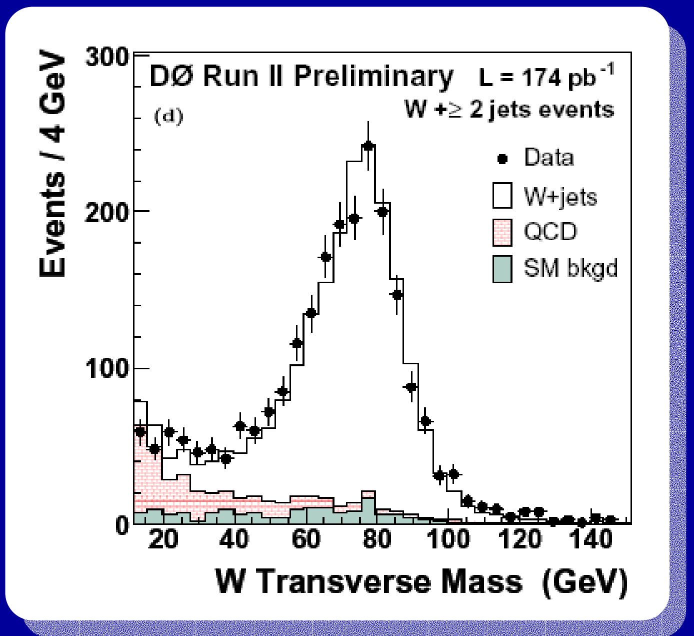
- Given the luminosities, we cannot yet exclude interesting M_H
- Focus on measuring the backgrounds
  – W/Z+heavy flavor, WW and top
- Improving signal significance
  – Mass resolutions
  – B-tagging
  – Advanced analyses techniques



Results presented here will be based on 150~180 pb^{-1} of data

$W+b\bar{b}$ (DØ)

- W+bb is an important background to WH
- Select W + 2 jets from 175 pb^{-1}
  - Electron: $p_T>20$ GeV
    $|\eta|<1.1$
  - Missing E_T: $E_T>25$ GeV
  - 2 Jets: $\not{p}_T>20$ GeV
    $|\eta|<2.5$
  - Veto dileton events
  - 2567 evts (2670 ± 838 expected)
- Instrumental background estimated from data



- Compared with ALPGEN LO MC
  - PYTHIA showering and full detetector simulation
  - Normalized to NLO x-section
- SM backgrounds
  Z + jets where $Z\to ee$ or $Z\to\tau\tau$, $W\to\tau\nu$, tt-bar, single top

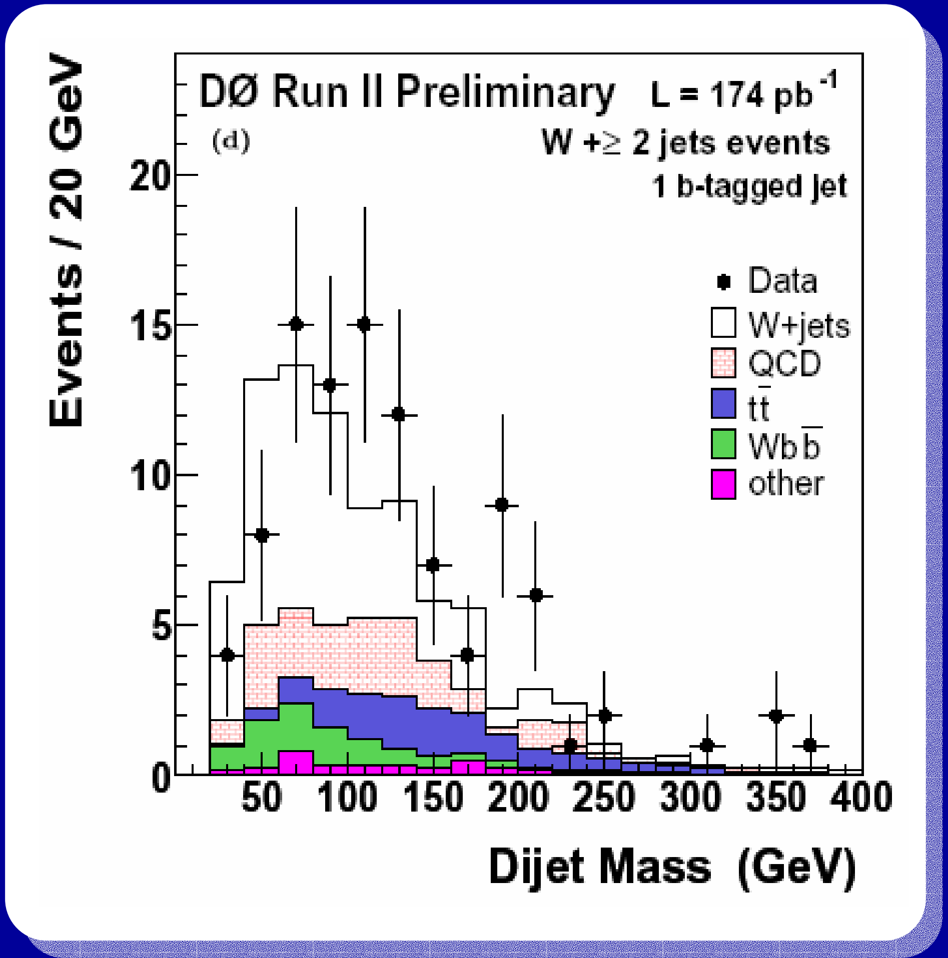
$W + b\bar{b}$ (DØ)

- Jet lifetime impact parameter tagging
  - One of 3 b-tagging algorithms at DØ

100 events observed

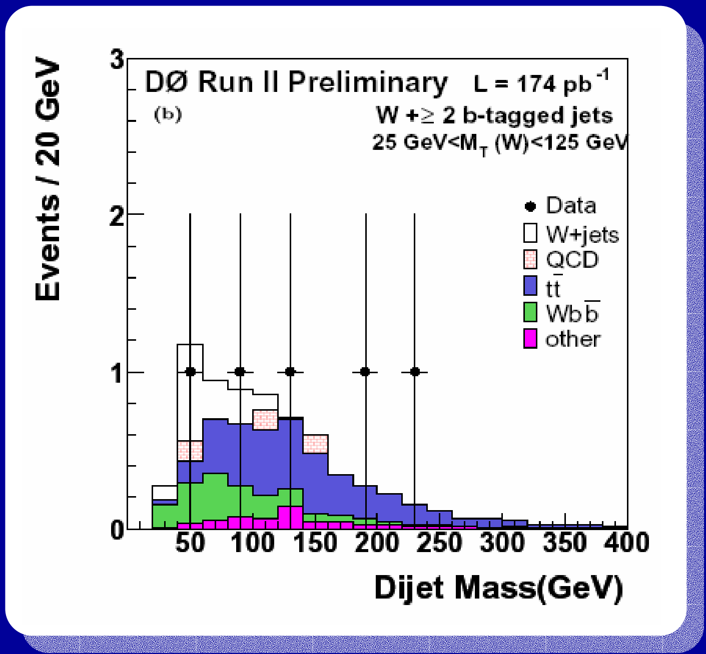
88 ± 23 events expected

Jet energy scale	X-section	effciencies
15	10	10

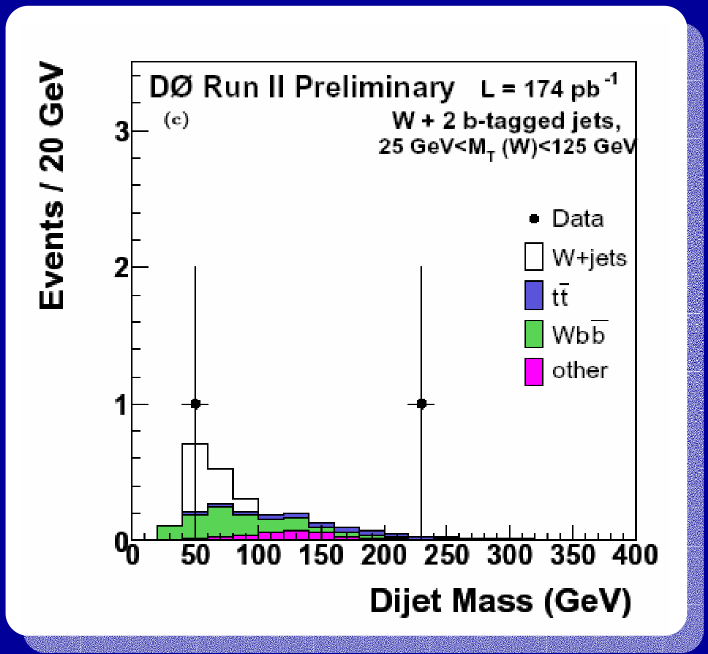


W + $b\bar{b}$ (DØ)

- Double b-tag analysis



- Veto on 3rd jet



QCD	tt-bar + single top	W+bb	W+jets	total
0.4	**3.8**	**2.1**	**0.6**	**6.9 ± 1.8**

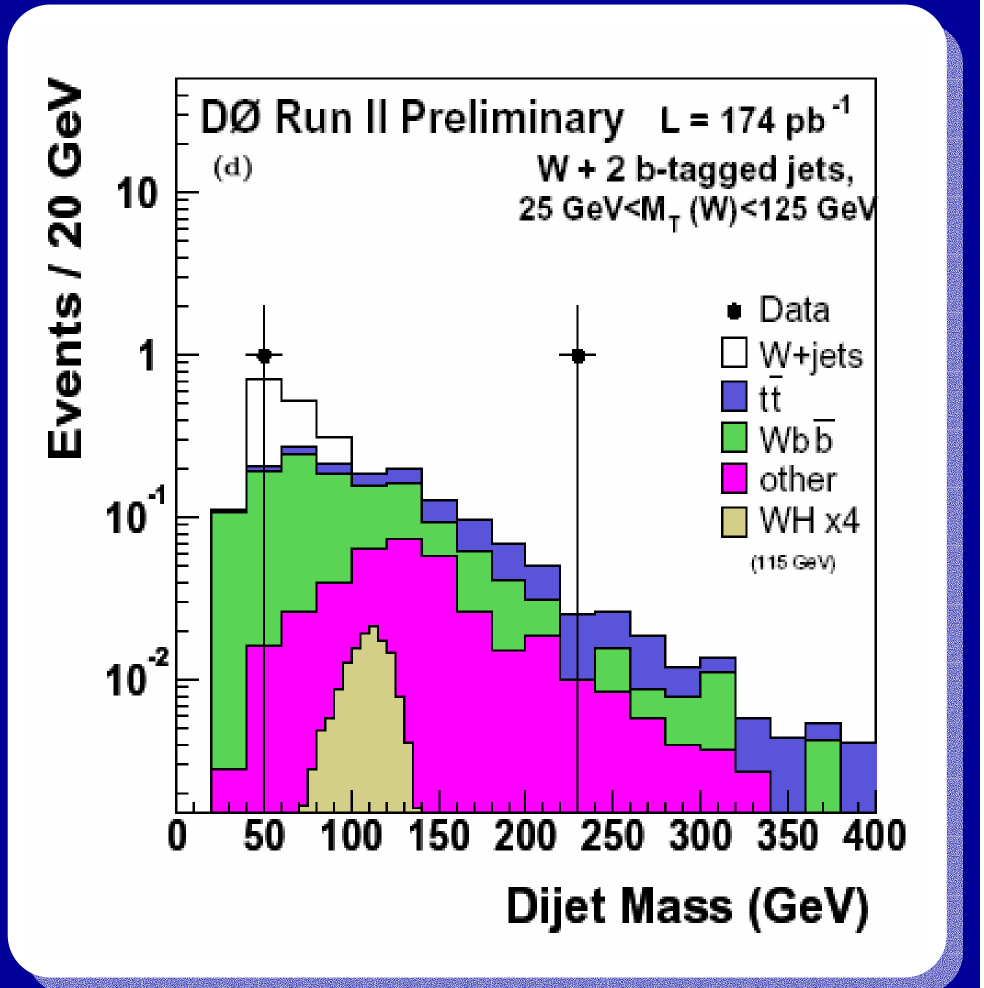
2.5 events expected and 2 events observed

$\sigma(Wbb)<20.3$ pb @95% CL

WH Cross Section Limit (DØ)

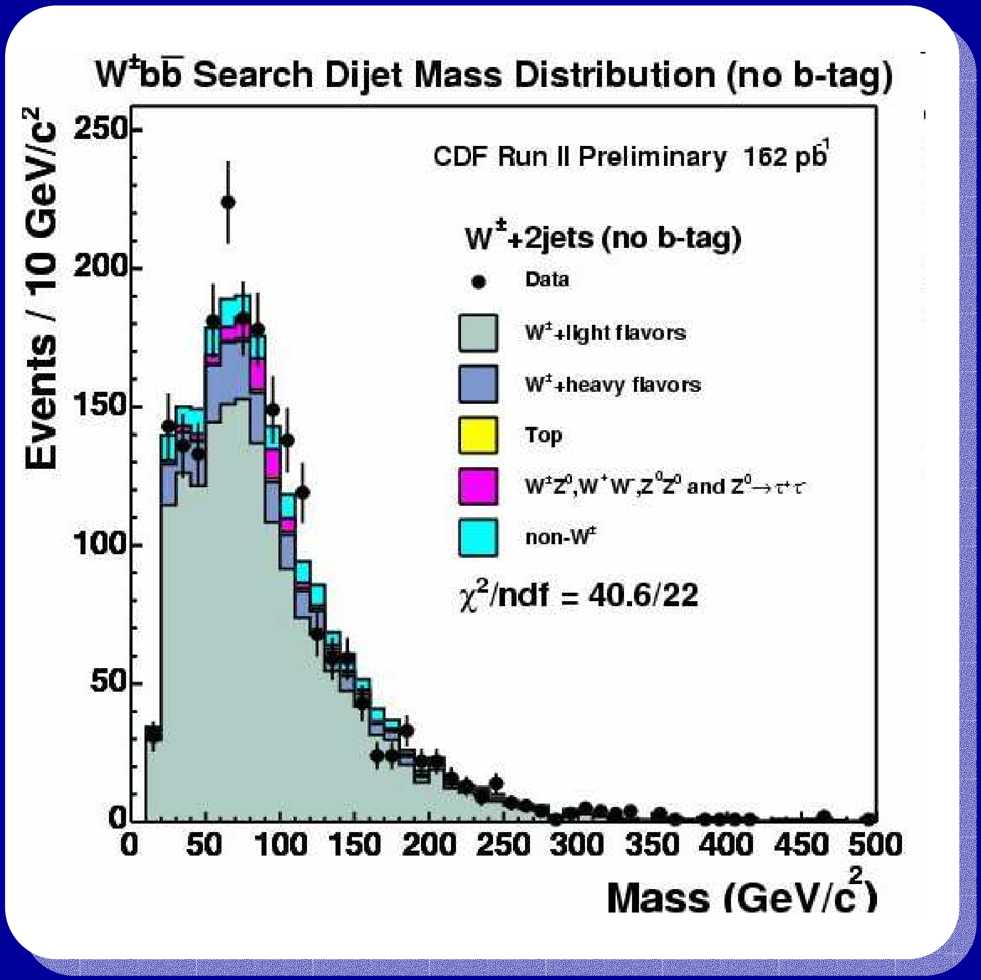
- Further improvement in signal significance is possible by requiring all 3 taggers fire
  - B-taggers are more correlated for real b's
- 2 events remain and 0.6 events expected
  - 0.3 Wbb
  - 0.1 for tt, single top, Wcc each
  - No Wbb is disfavored at 2σ

For M_H=115 GeV Higgs,
$\sigma(WH)\times BR(H\rightarrow bb)$ < 12.4 pb (95% CL)



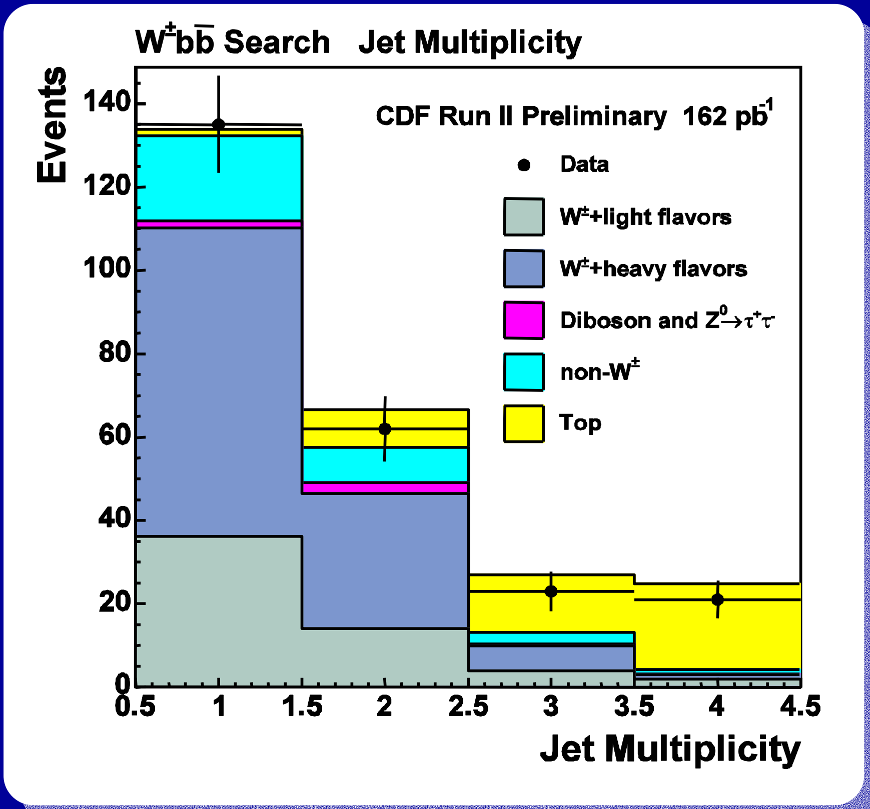
WH Searches (CDF)

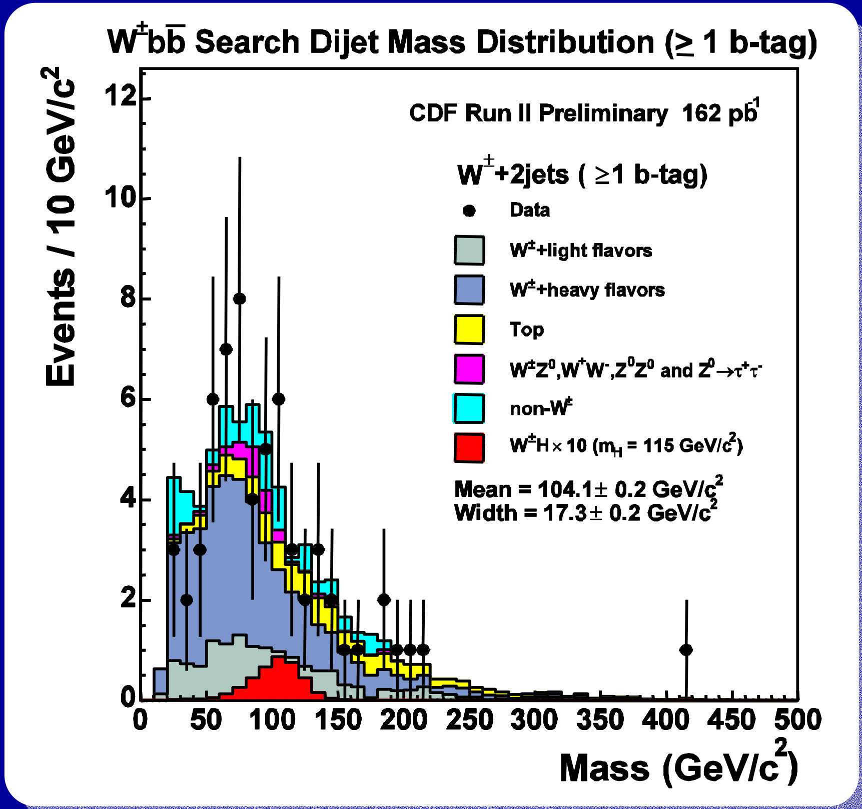
- Using 162pb^{-1} of data in muon and electron channels
- Event selection
  - Inclusive lepton trigger
  - lepton: p_T>20 GeV central region
  - Missing E_T: $\not{E}_T$>20 GeV
  - 2 Jets: p_T>15 GeV $|\eta|$<2.5
- Veto on
  - Additional high p_T track
  - 3rd and 4th jet



WH Searches (CDF)

- Single b-tag analysis
  - Secondary vertex tagging
- 3rd jet vetoed
  - 62 events (67±9 expected)

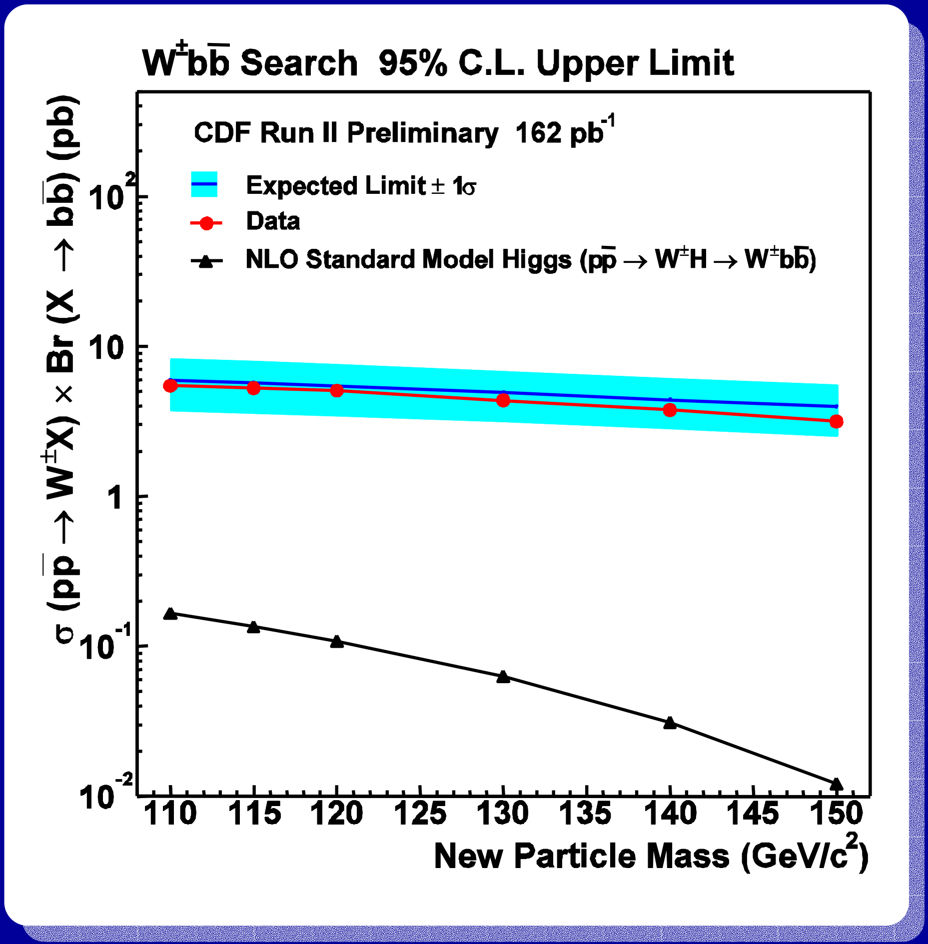




WH Cross Section Limit (CDF)

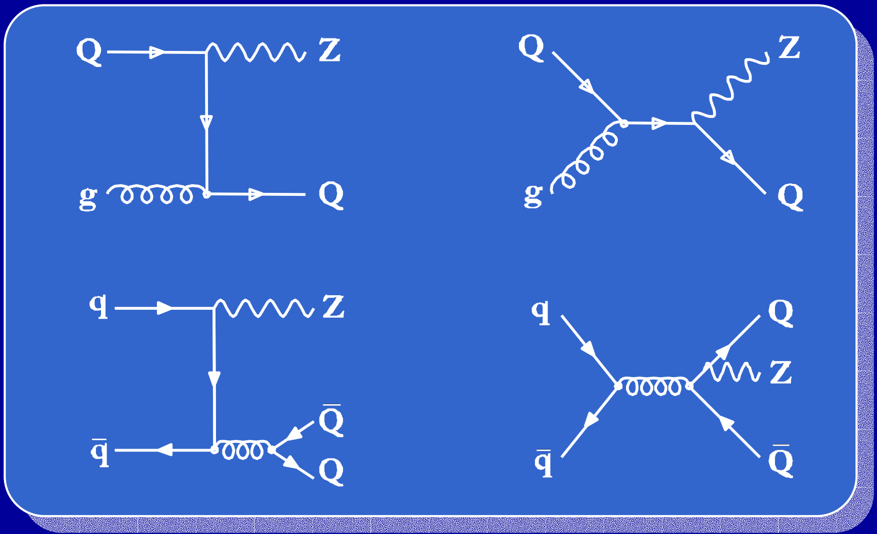
- < 5 pb @ 95% C.L.
  - Systematic uncertainty in efficiency*acceptance

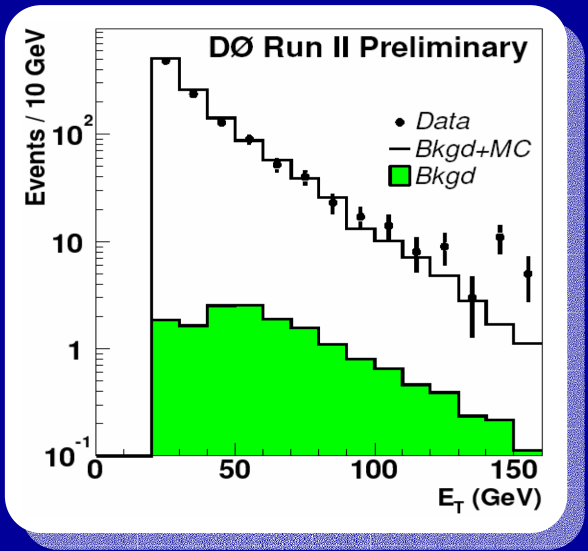
Sources	%
FSR	7
ISR	4
SECVtx	6
Total	11



Z + Heavy Flavor Production (DØ)

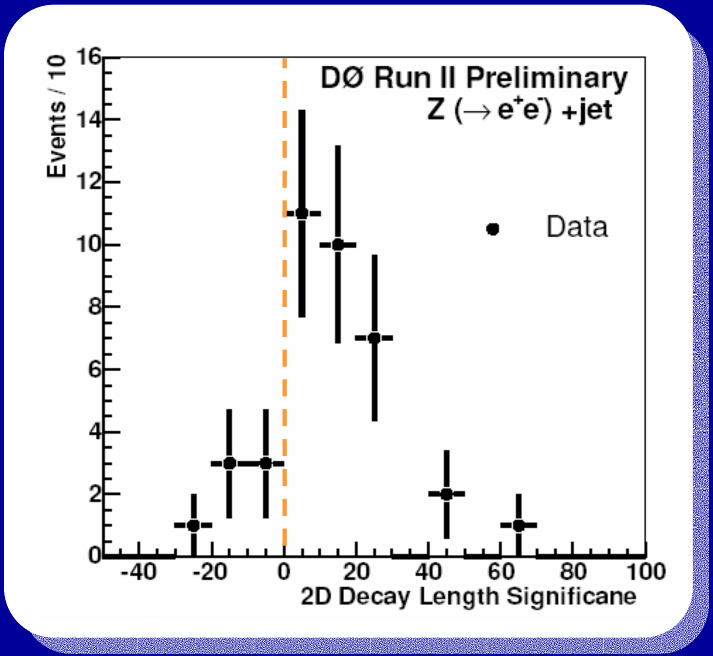
- Z+heavy flavor is background to ZH
- Z + single b-tag
  - Probe of b-quark PDF
  - b PDF is important for *hb* and *single-top* production
- Measure $\sigma(Z+b)/\sigma(Z+j)$
  - Many systematics cancel
- Selection
  - Z in ee and $\mu\mu$ channels (cut on mass window)
  - $\geq$1 Jet p_T>20 GeV, $|\eta|$<2.5
  - 3458 Z+jet events





$\sigma(Z+b)/\sigma(Z+j)$ (DØ)

- Apply sec. vertex b-tag
  - 42 events with ≥1 tag
  - 8.3 from QCD background (sideband)

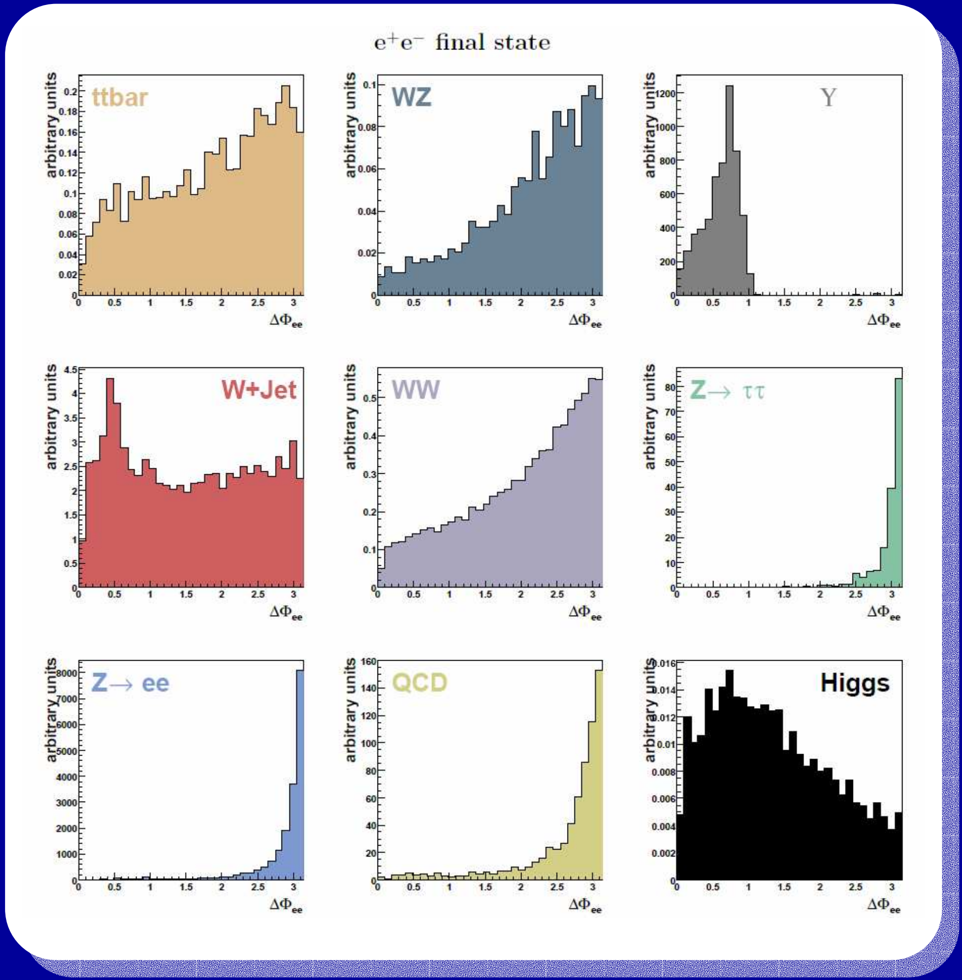


- Disentangle light, c, b contributions
  - Use light and b-tagging efficiency from data
  - c-tagging efficiency from MC and scaled for data/MC difference in b-tagging
  - $N_c=1.69N_b$ from theory
- Cross checks with
  - Soft lepton tagger
  - Impact parameter tagger
- 0.024±0.005(stat)±0.005(syst)
  - Theory predicts 0.018
  - Large part of systematic error from tagging efficiency and background estimation

WW Production and Searches for H→WW

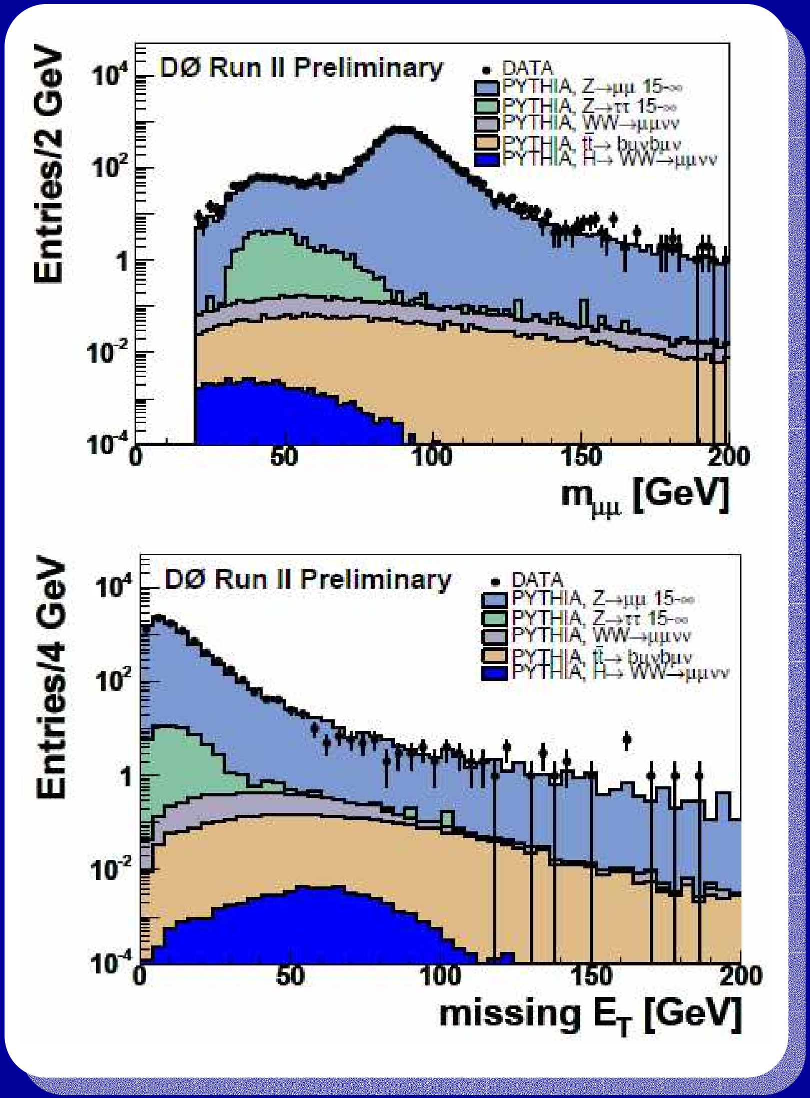
- WW in 2 leptons + MET
  - CDF: 14.3 $^{+5.9}_{-5.2}$ pb
  - DØ: 13.8 $^{+4.5}_{-4.9}$ pb

- Look for excess in the leptonic decay mode
  - Explicit mass cannot be reconstructed
  - WW decays from a spin 0 particle
  - ☞ leptons prefer to decay in the same direction

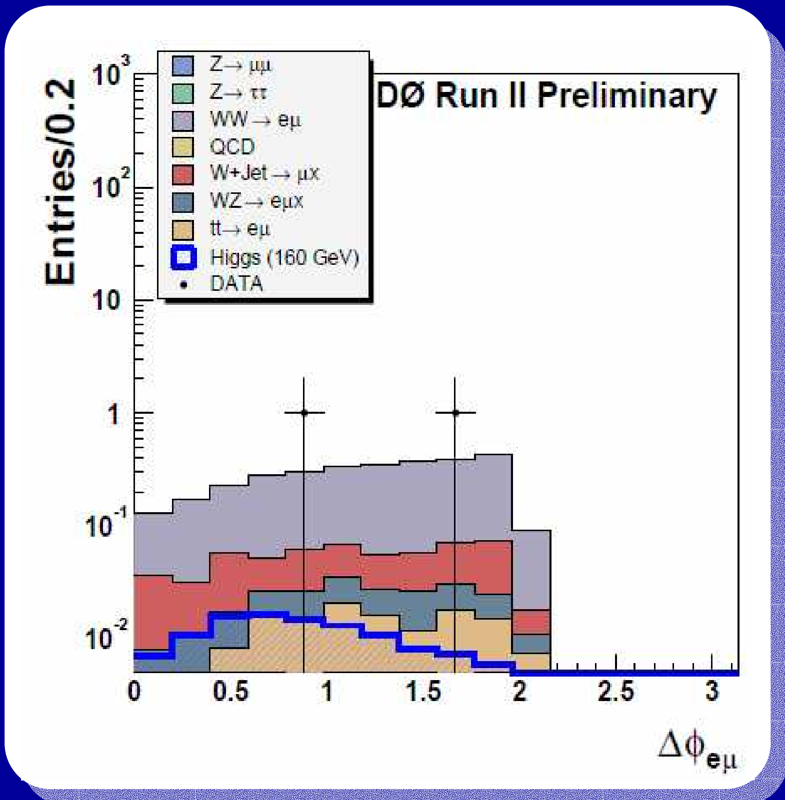


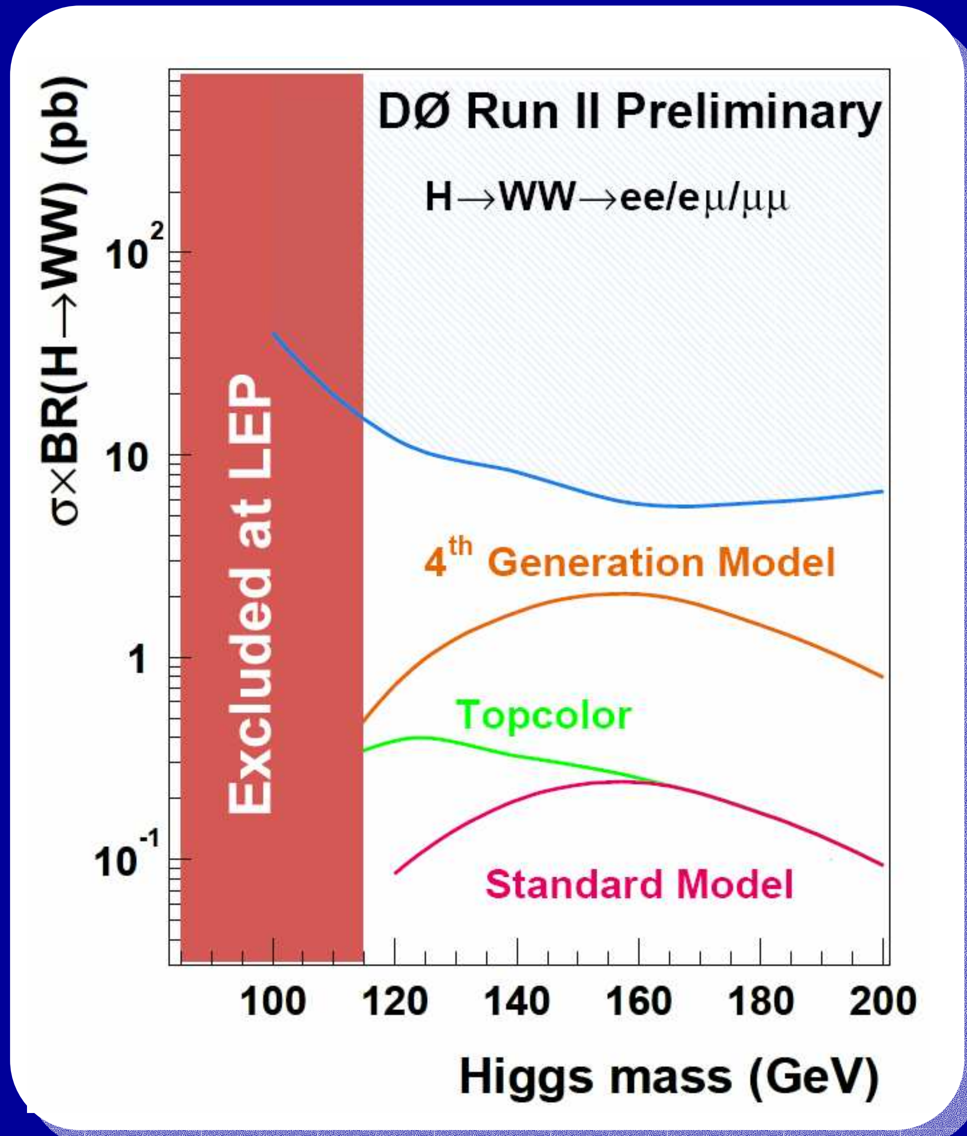
H→WW (D0)

- Search done in 3 channels
  - ee, eμ, μμ
  - 147~177 pb^{-1} of data
- Selection
  - 2 oppositely charged leptons
  - Large MET
  - Dilepton mass or min($M_T(e)$, $M_T(\mu)$)
  - Scalar sum of lepton p_T and MET
  - Jet veto
  - $\Delta\Phi_{ll}$
  - ☞ beat down Z, W+jets, tt-bar
- Cuts optimized for each mass point



$H \rightarrow WW$ (D0)



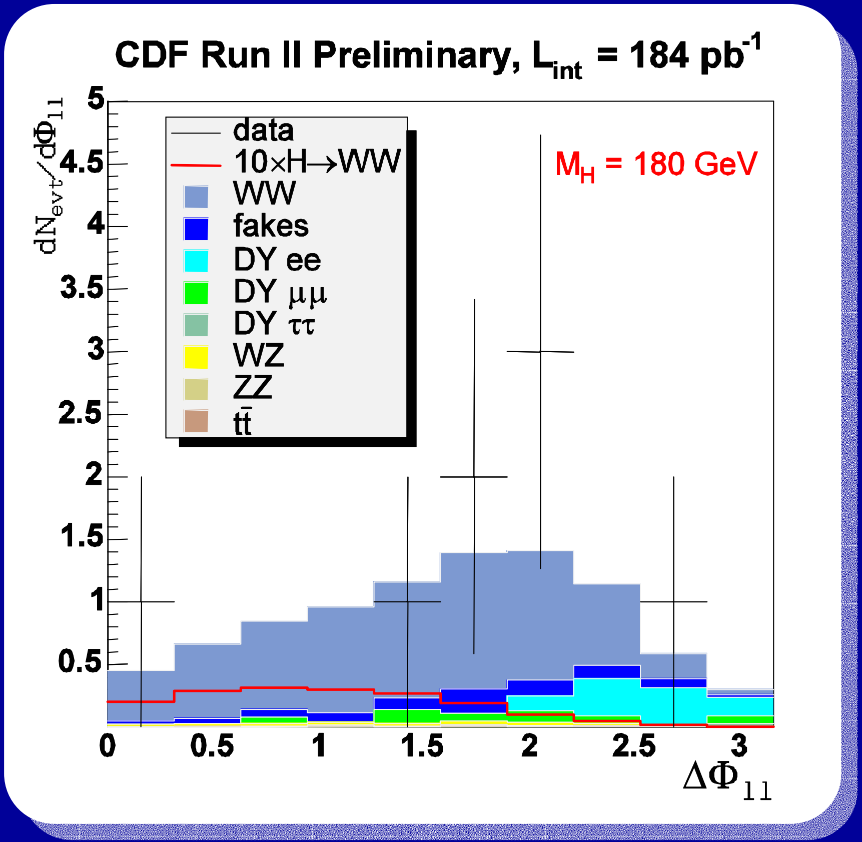


- Limit set in each channel by counting
- Combine the likelihoods

σ*BR($H \rightarrow WW$) < 5.7pb
For M_H=160 GeV

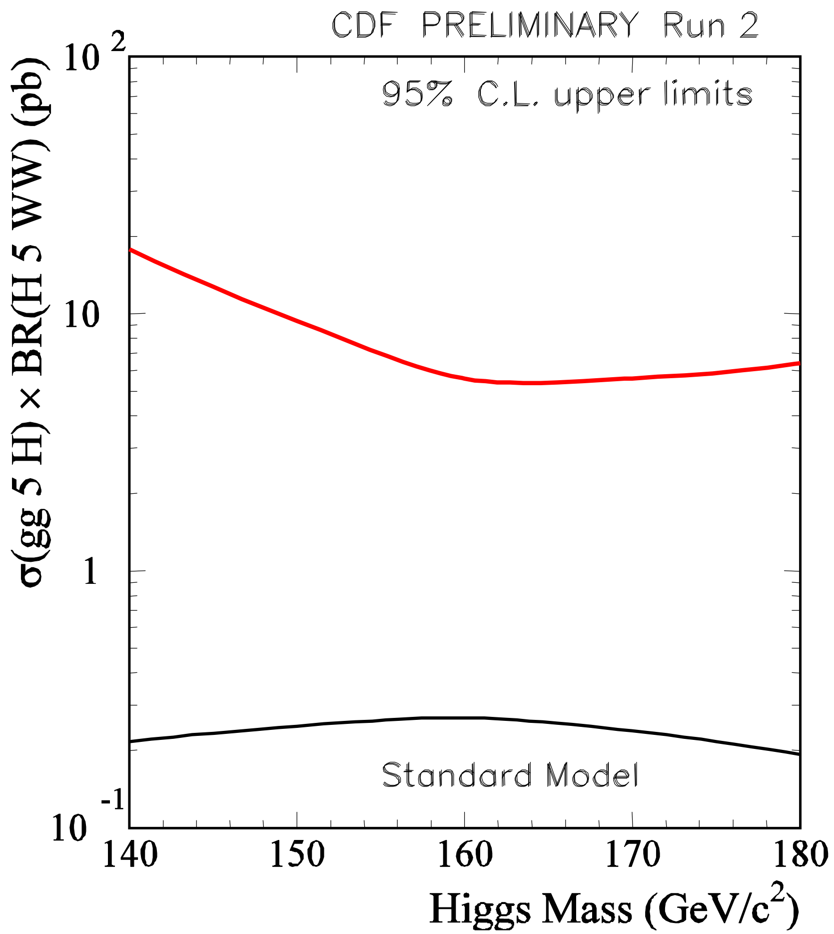
H→WW (CDF)

- Seach in 3 channels
  - ee, eμ and μμ
- Selection
  - 2 isol. leptons p_T>20 GeV
  - MET > 25 GeV
  - Veto on jets E_T>15, |η|<2.5
- 8 events observed
  - 8.9±1.0 expected
- Limits are extracted by performing the likelihood fit to the $\Delta\Phi_{ll}$ distribution



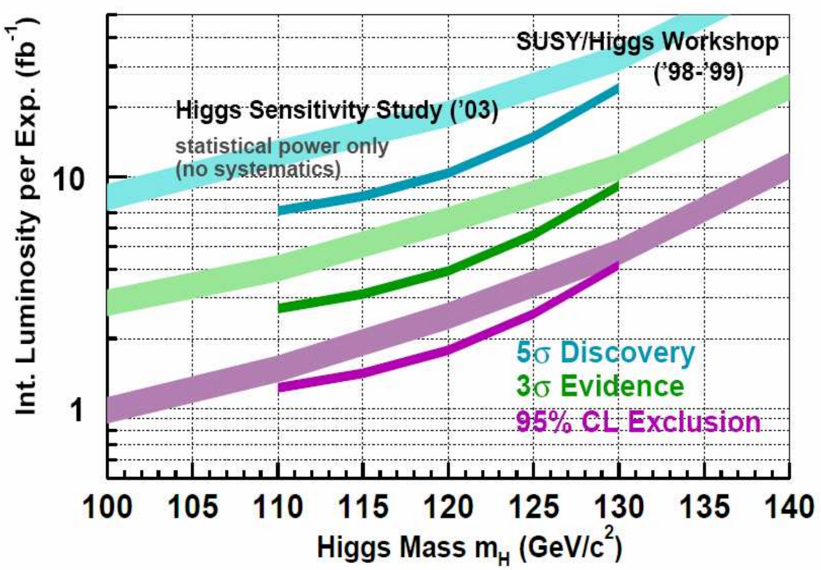
WW	Drell-Yan	Fakes
6.5 ± 0.8	1.3 ± 0.5	0.81 ± 0.25

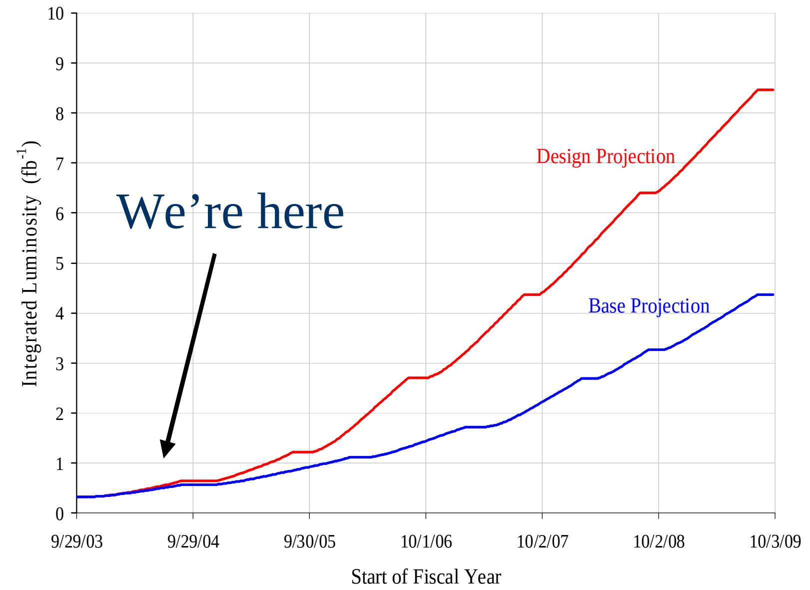
H→WW (CDF)



σ*BR(H→WW) < 5.6pb
@ 95% CL
For M_H=160 GeV

Outlook





- Need >2 fb^{-1} per experiment to rule out interesting M_H regions
- Working on further optimization
- Benchmark: $WZ \rightarrow l\nu bb$

- Excellent performance of the Tevatron
  - Met the design projection for this year
- Need to understand high luminosity environment

Conclusion

- We have begun searching for the Higgs
  - Background event yields well understood
  - Working towards reaching ultimate sensitivity
- Exciting period lies ahead of us in the quest for Higgs